

Trial No: DM0307

Title: Investigation into irrigation practices and crop water use for Protea (Pink Ice) at Childers



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SUMMARY

Enviroscan equipment and crop growth measurements were used in a crop of Protea (Pink Ice) at Childers, Queensland, to investigate the crop water use pattern and obtain data to assist with the improvement of irrigation practices.

Crop and soil monitoring occurred from early October to early December. The stand out weather conditions during the period was a 70mm rainfall event in early October and a similar rainfall event in early November with other small rainfall events being of no significance. Irrigations of 2-5 hours were made at approximately 5 day intervals or 5 days after rainfall, with a few exceptions.

The results from the soil moisture monitoring over the period show high soil moisture levels for the two rainfall events with a dip in soil moisture in the middle. This dip in soil moisture between rainfall events coincides with a reduction in crop growth rate. Overall results indicate the irrigation interval should be reduced to every 4 days at 3 hours to meet crop demand.

Crop water use pattern matched the placement of the irrigation water through the soil profile. The majority (95-100%) of crop water use was in the top 30-50cm of soil.

Tensiometers placed at 30cm depth were found to be a useful tool for irrigation scheduling. A reading of 40 indicates irrigation should commence.

AIMS

1. To determine effective crop rooting depth and crop water use of Protea (Pink Ice) at the Childers site
2. To find where improvements in irrigation efficiency could be made

SITE DETAILS

Location: Childers, Qld

Crop Details:

Type: Protea (*Protea repens*)

Variety: Pink Ice

Age: Planted 2003

Density: Single rows, 5m between rows and plant spacing 1m along the row
= 2,000 approximately trees/ha

Mound Planted: Crop planted into mounds with a width of 2m and height approximately 30-40cm. Weeds are controlled by herbicide spraying. The inter-row area is grass. Pruning material and grass from the inter row area is broken up by the slasher and directed onto the mounds, providing a thin mulch covering.

Crop Growth Stage at 3rd October 2007: Plants were approximately 2.4m high and 2.2m canopy width.

Soil Type

Grey sandy loam to 60cm with a slight tinge of yellow at 70cm and slight change in soil texture.

Irrigation Setup

Water source: Dam – collects the runoff from the farm area

Water quality: Tested and found to be very suitable for irrigation

Irrigation Type: Pressure compensating drip line placed on the surface in the middle of the beds.

Emitter outlet 1.6L/hr

Emitter spacing: 50cm – spaced to have an outlet at the base of each plant and one between each plant.

MATERIALS & METHODS

Irrigation Uniformity

Irrigation uniformity was measured by collecting irrigation water for 5 outlets per row on 3rd October 2007.

Soil Moisture Measurement

An Enviroscan logger with 2 probes each with 4 sensors at 10, 20, 30, 50 and 70cm were installed in early October 2007. Probes were positioned within 5cm of the emitter between trees along the row. Probes were installed in adjacent rows. Plants in these rows were of similar size and appearance with a common history of maintenance, nutrition and irrigation.

Calculations were made on crop water use at the various soil depths using data from the enviroscan graphs. The percentage of soil moisture extracted from the various soil depths was calculated from this data. The daily crop water use was calculated from the interpolated enviroscan graphs. Please note that because the sensors were not placed at 10 cm intervals, the interpolated soil moisture reading was used for the total soil moisture. This is not the same as the sum of the individual sensors – a calculation is made to compensate for the missing sensors along the probe when using the interpolated data.

Jet Fill tensiometers at 30cm depth were also installed in November between plants and next (within 5cm) to a drip emitter outlet in the rows containing the enviroscan probes.


Stem Growth Measurements

Commencing 3rd October, 20 stems of similar appearance and length were selected from 3 consecutive plants in each of the datum rows where the soil moisture measuring equipment was located. Stem length was measured from the base of the stem (from the point of pruning) to the top of the foliage. This work was conducted by the grower.

RESULTS
Crop Growth

Table 1: Growth (cm) of stems from 6th October to 24th November 2007

Stem Number	6-Oct	13-Oct	20-Oct	28-Oct	3-Nov	10-Nov	18-Nov	24-Nov
1	50.5	52	52.5	53	55	59	63.5	66
2	59	61	62	62	62	62	F	F
3	58.5	60	62.5	64	70	73	75.5	76
4	54.5	55.5	56	58	62.5	65	68	70
5	55	58	58	58	58	58	F	F
6	56	57.5	57.5	58	58.5	58.5	F	F
7	52.5	56	56	56	56	60	66	74
8	57.5	59.5	59.5	60	60	66	72.5	74
9	56	59	60	61	61	61	F	
10	54	56	57	60	64	68	69.5	71.5
11	52	53	53	53.5	58	62	65	66
12	52	54	54.5	54.5	54.5	54.5	55	F
13	52	53	53	53	53	53	53	
14	55	57	57.5	57.5	60	65	69	70.5
15	51	53	53.5	54	54	59	64	66
16	53.5	55	55	56	56	56	56	F
17	50.5	52	55.5	53	56	59	64	64
18	53	55	55.5	55.5	55.5	58	64	65.5
19	56	57	57.5	60	64	67	70	70.5
20	54	55	55.5	56	56.5	58	63	65
Average stem length	54.13	55.93	56.58	57.15	58.73	61.10		
Growth rate cm/day		0.26	0.09	0.07	0.26	0.34		
Average stem length and growth rate not including Flowering plants								
Average stem length	53.77	55.46	56.27	56.96	59.35	63.00	67.23	69.15
Growth rate cm/day		0.24	0.12	0.09	0.40	0.52	0.53	0.32

 Flower head developing by 10/11/2007

Irrigation and Rainfall

Table 2: Irrigation, rainfall (mm) and Tensiometer readings

Date	October			November			December		
	Rain	Irrigation	Tensiometer	Rain	Irrigation	Tensiometer	Rain	Irrig	Tensiometer
1							8		10
2									
3					w 3h	40			
4									
5							w 6h		12
6		w 3h	25	40					
7		w 1.5h		20					
8				15					
9	7								
10	36		14			20			
11	15								
12	12								
13			14		w 3h				
14									
15									
16									
17		w 3.5h	40						
18						40			
19					w 5.5 h				
20			30						
21	7					32			
22		w 2.5			w 2.5				
23									
24			44			50			
25									
26					w 5.5				
27									
28		w 2h	42						
29	7								
30				4	w 5.5	36			
31		w 3h	16						
Total Rain	84	6 Irrig 15.5 h		64	6 Irrig				
LTA	70			90					

W = an irrigation was made: h = irrigation time in hours: LTA = long term average rainfall

Emitter output

Results of collection from 5 outlets showed the 1.6L/hour output was correct and very uniform.

Crop water use data obtained from enviroscan graphs

Note: Interpolated is the calculated soil moisture content for the total depth of soil to 70cm and not the sum of the readings from the sensors.

Table 3: Crop water use at commencement of monitoring

Sensor Depth	Date 6-Oct	7-Oct	Water use mm/day	% Water use at each sensor depth
10 cm	22.94	20.05	2.89	28.90
20 cm	22.2	19.54	2.66	26.60
30 cm	20.28	17.83	2.45	24.50
50 cm	15.54	14.19	1.35	13.50
70 cm	14.6	13.95	0.65	6.50
Interpolated	128.5	115.6	12.9	

Table 4: Crop water use after 70mm rainfall (9th -12th October)

Sensor Depth	13-Oct	14-Oct	use	%	15-Oct	use	%	16-Oct	Use	%	17-Oct	use	%
10 cm	28.8	25.55	3.25	34.14	22.74	2.81	25.52	20.2	2.54	27.70	19.09	1.11	18.94
20	28.2	26.2	2	21.01	22.9	3.3	29.97	20.2	2.7	29.44	18.31	1.89	32.25
30	24.07	22.35	1.72	18.07	19.84	2.51	22.80	17.7	2.14	23.34	16.11	1.59	27.13
50	18.93	16.68	2.25	23.63	14.7	1.98	17.98	13.4	1.3	14.18	12.47	0.93	15.87
70	15.8	15.5	0.3	3.15	15.09	0.41	3.72	14.6	0.49	5.34	14.26	0.34	5.80
Interp	154.7	141.9	12.8		127.6	14.3		115.9	11.7		106.9	9	

Table 5: Crop water use following a 2.5 hour irrigation (22nd Oct)

Sensor Depth	23-Oct	24-Oct	use	%	25-Oct	use	%	26-Oct	use	%	27-Oct	use	%
10cm	21.85	19.31	2.54	29.43	17.12	2.19	27.07	15.38	1.74	27.19	14.06	1.32	27.27
20	23.54	20.73	2.81	32.56	18.09	2.64	32.63	16.28	1.81	28.28	14.91	1.37	28.31
30	20.32	17.75	2.57	29.78	15.49	2.26	27.94	13.78	1.71	26.72	12.48	1.3	26.86
50	14.08	13.28	0.8	9.27	12.28	1	12.36	11.48	0.8	12.50	10.88	0.6	12.40
70	13.49	13.58	0.09	-1.04	13.58	0	0.00	13.24	0.34	5.31	12.99	0.25	5.17
Interp	124.3	113.6	10.7		103.2	10.4		95.14	8.06		88.94	6.2	

Table 6: Crop water use with low soil moisture levels

Sensor Depth	1-Nov	2-Nov	use	%	3-Nov	use	%
10cm	22.54	20.53	2.01	30.23	18.66	1.87	32.08
20	22.34	20.04	2.3	34.59	18.14	1.9	32.59
30	17.45	15.53	1.92	28.87	14.05	1.48	25.39
50	11.39	11.03	0.36	5.41	10.53	0.5	8.58
70	11.86	11.8	0.06	0.90	11.72	0.08	1.37
Interp	111.6	103.6	8		96.5	7.09	

Table 7: Crop water use after 75mm rainfall (6th – 9th November)

Sensor Depth	10-Nov	11-Nov	Mm use/day	% use over 70cm	12-Nov	use	%	13-Nov	use	%
10cm	21.2	19.23	1.97	19.28	17.79	1.44	18.07	15.96	1.83	23.74
20	25.39	23.03	2.36	23.09	20.9	2.13	26.73	19.01	1.89	24.51
30	24.89	22.53	2.36	23.09	20.57	1.96	24.59	18.66	1.91	24.77
50	24.76	21.2	3.56	34.83	19.05	2.15	26.98	17.38	1.67	21.66
70	20.61	20.64	-0.03	-0.29	20.35	0.29	3.64	19.94	0.41	5.32
Interp	164.3	149.4	14.9		138.2	11.2		127.6	10.6	

Enviroscan soil moisture levels before and after irrigation and rainfall

Table 7: Soil moisture changes after a 2 hour irrigation event

Sensor Depth	28-Oct	28-Oct	Soil moisture Increase (mm)	%Increase
10 cm	12.67	22.9	10.23	47.49
20	13.31	22.53	9.22	42.80
30	10.8	13.03	2.23	10.35
50	10.13	10.03	-0.1	-0.46
70	12.59	12.55	-0.04	-0.19
Interpolated soil moisture (mm)	81.32	103.9	22.58	

Table 8: Soil moisture changes after a 3 hour irrigation event

Depth	3-Nov	3-Nov	Soil moisture Increase (mm)	%Increase
10 cm	18.67	26.26	7.59	29.33
20	17.12	28.62	11.5	44.44
30	12.9	19.71	6.81	26.31
50	10.12	10.08	-0.04	-0.15
70	11.57	11.59	0.02	0.08
Interpolated soil moisture (mm)	92.57	122	29.43	

Table 9: Soil moisture changes after a 5 hour irrigation event

Depth	19-Nov	19-Nov	Soil moisture Increase (mm)	%Increase
10 cm	14.96	22.27	7.31	27.16
20	15.94	24.23	8.29	30.81
30	13.84	21.66	7.82	29.06
50	13.88	17.05	3.17	11.78
70	18.56	18.88	0.32	1.19
Interpolated soil moisture (mm)	107.2	141.4	34.2	

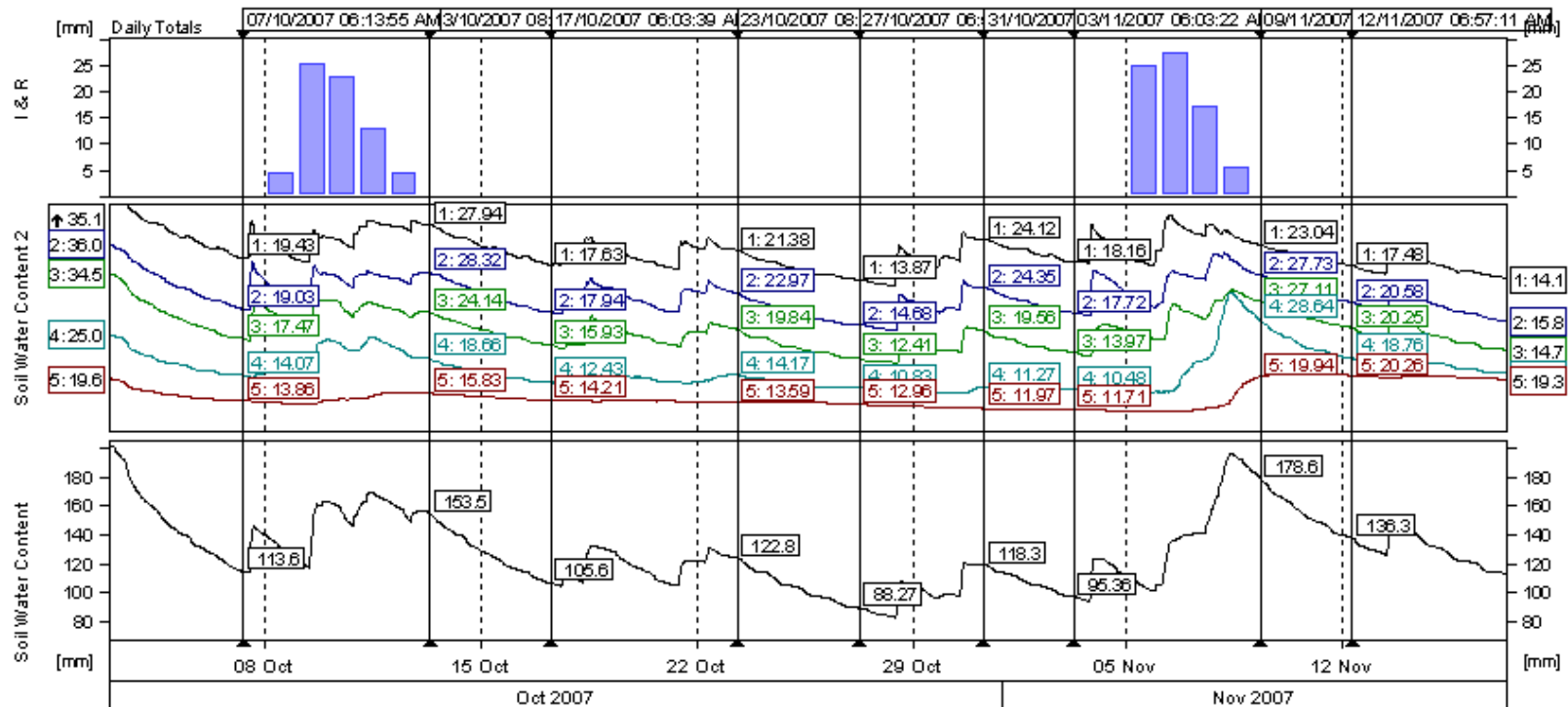
Table 10: Increase in soil moisture after 75mm rainfall(6-8th Nov)

Sensor Depth	6-Nov	7-Nov	8-Nov	9-Nov	10-Nov
10 cm	17.49	25.85	25.98	21.53	19.62
20	19.77	26.87	31.91	26.06	23.64
30	17.42	23.39	29.81	25.4	22.9
50	9.88	17.48	35.58	25.62	21.66
70	11.33	11.71	14.09	20.47	20.61
Interpolated soil moisture (mm)	100.1	140.3	194.9	167.6	151.8
Change		40	55		-15.8

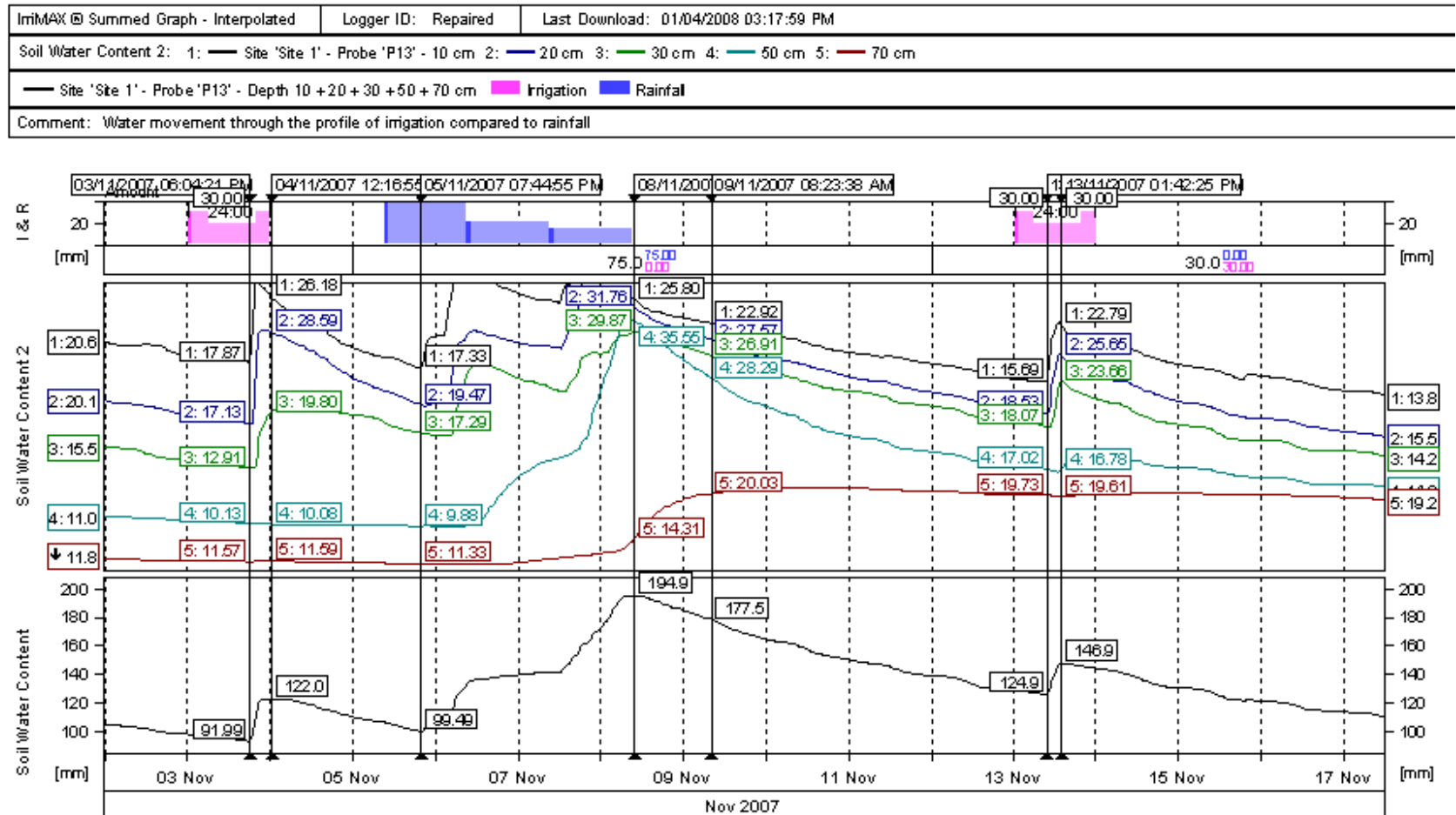
Enviroscan Graphs

Graph 1: Comparison of interpolated summed and stacked graph for the period of the crop monitoring

ImiMAX © Summed Graph - Interpolated	Logger ID: Repaired	Last Download: 01/04/2008 03:17:59 PM
Soil Water Content 2: 1: — Site 'Site 1' - Probe 'P13' - 10 cm 2: — 20 cm 3: — 30 cm 4: — 50 cm 5: — 70 cm		
— Site 'Site 1' - Probe 'P13' - Depth 10 +20 +30 +50 +70 cm Irrigation Rainfall		
Comment: Graph for the period of crop monitoring 6th October to 24th November		

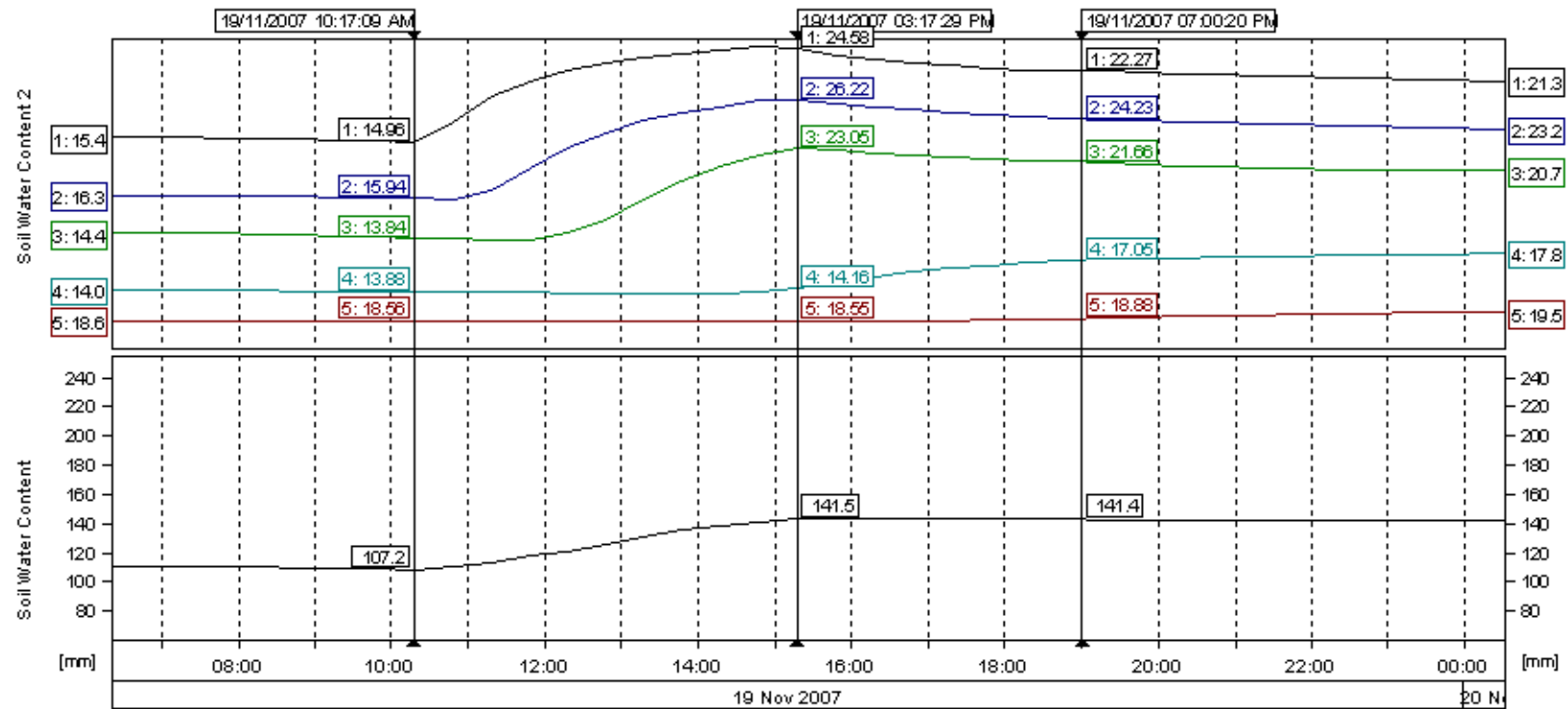


Graph 2: Comparison of soil moisture changes between 3 hour irrigations and a 75mm rainfall event

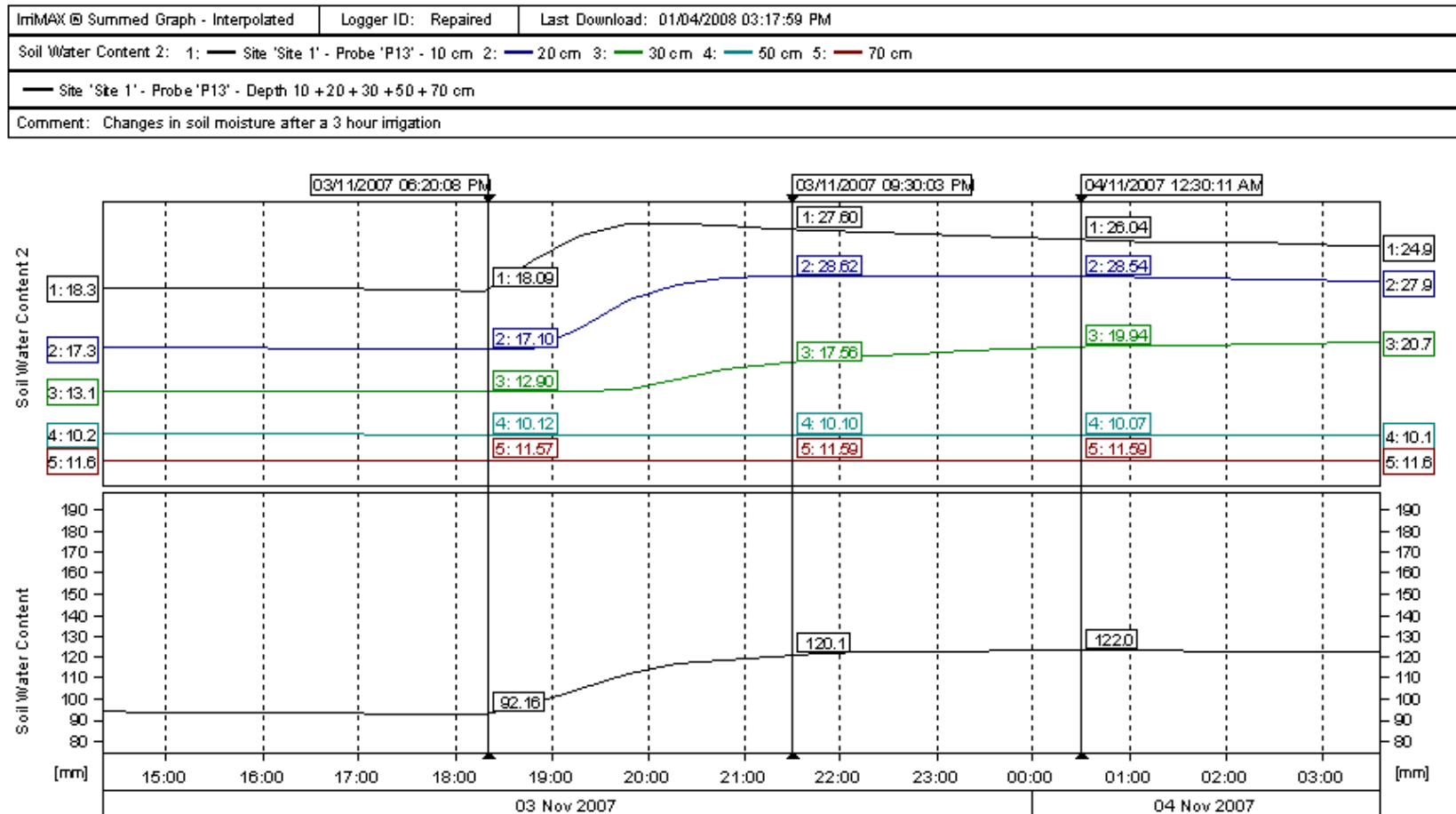


Graph 3: Changes in soil moisture content after a 5 hour irrigation

ImiMAX @ Summed Graph - Interpolated	Logger ID: Repaired	Last Download: 01/04/2008 03:17:59 PM
Soil Water Content 2: 1: — Site 'Site 1' - Probe 'P13' - 10 cm 2: — 20 cm 3: — 30 cm 4: — 50 cm 5: — 70 cm		
— Site 'Site 1' - Probe 'P13' - Depth 10 + 20 + 30 + 50 + 70 cm		
Comment: Changes in soil moisture with a 5 hour irrigation		

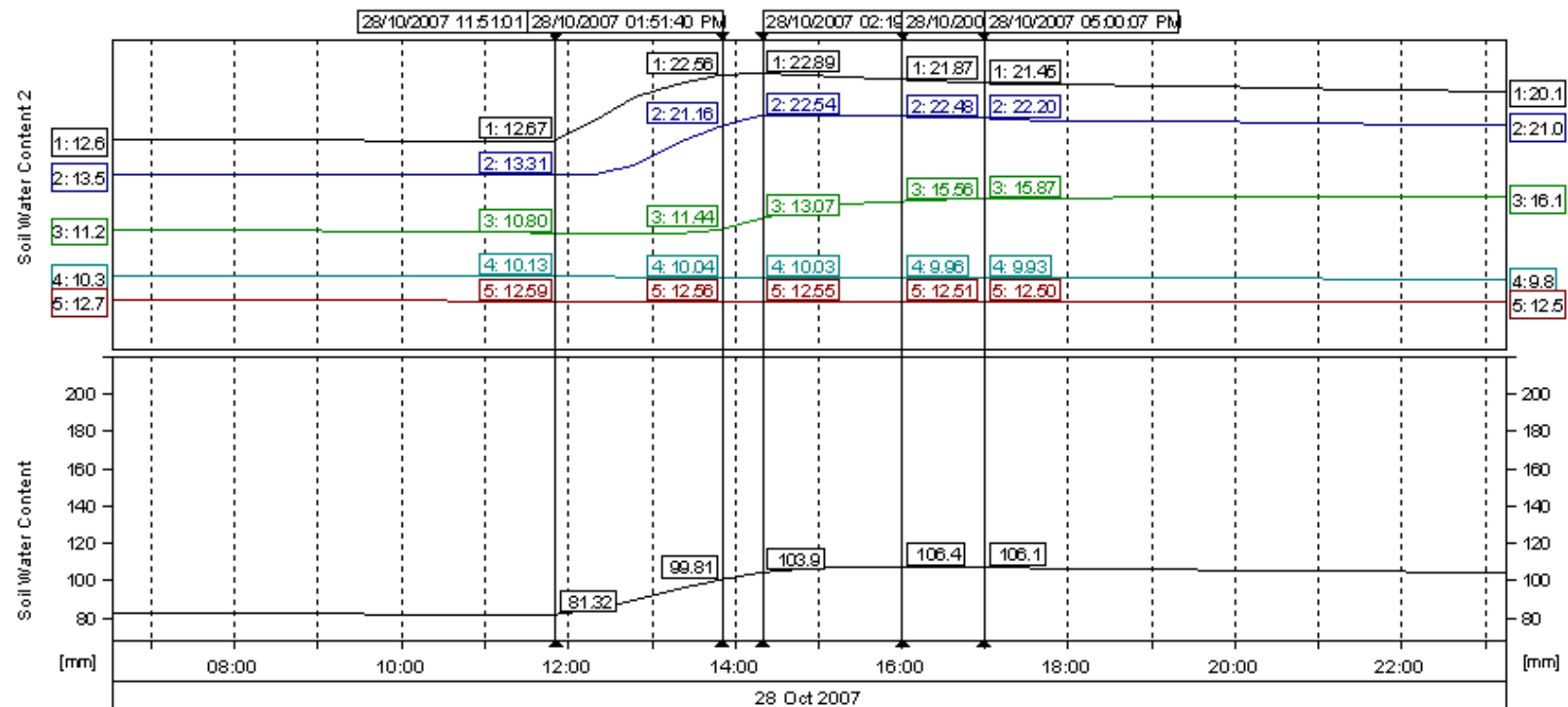


Graph 4: Changes in soil moisture with a 3 hour irrigation event

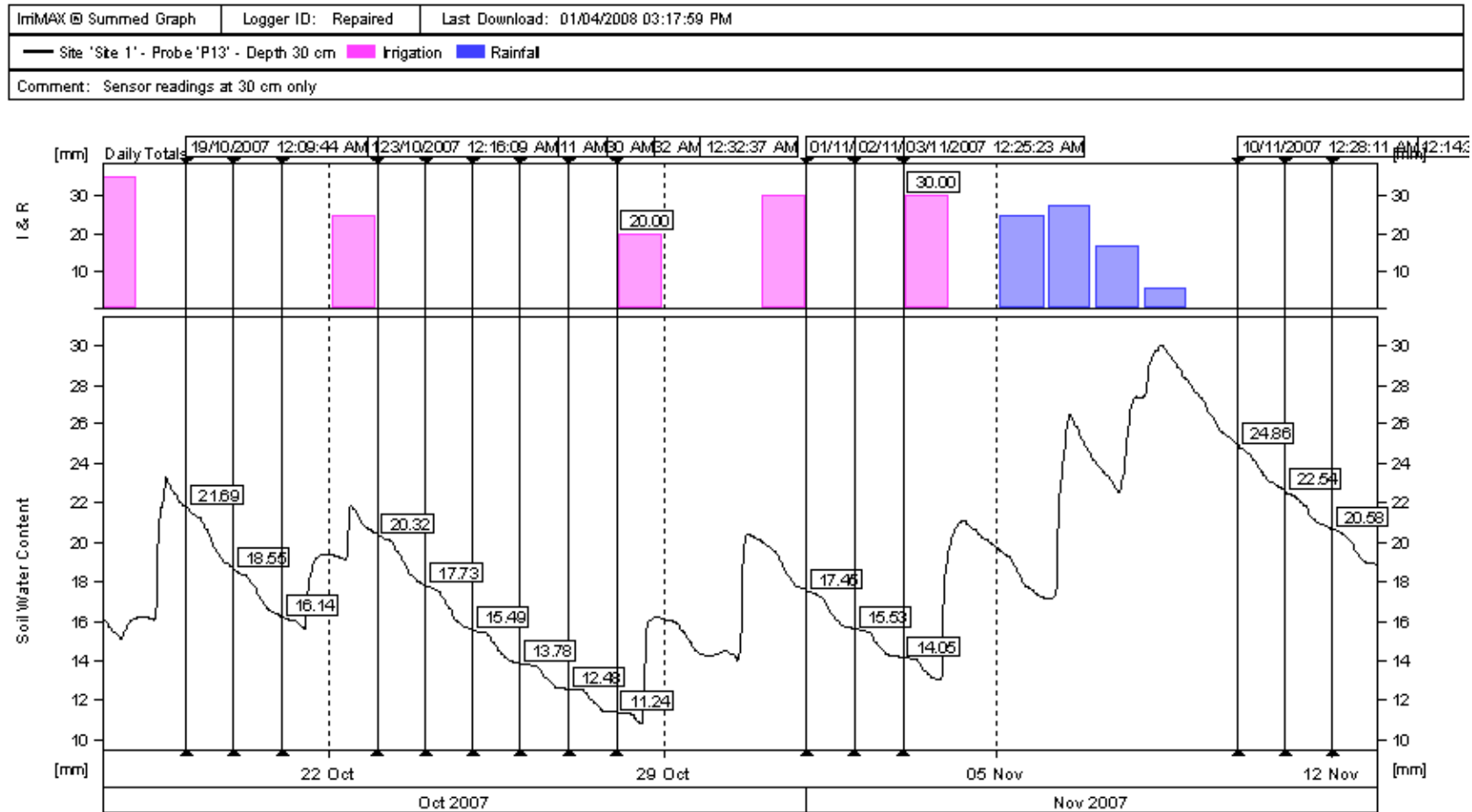


Graph 5: Changes in soil moisture after a 2 hour irrigation event

ImiMAX @ Summed Graph - Interpolated	Logger ID: Repaired	Last Download: 01/04/2008 03:17:59 PM
Soil Water Content 2: 1: Site 'Site 1' - Probe 'P13' - 10 cm 2: 20 cm 3: 30 cm 4: 50 cm 5: 70 cm		
— Site 'Site 1' - Probe 'P13' - Depth 10 +20 +30 +50 +70 cm		
Comment:		



Graph 6: Sensor readings at 30cm only



DISCUSSION

Overall Comment

Crop and soil monitoring occurred from early October to early December. The stand out weather conditions during the period was a 70mm rainfall event in early October and a similar rainfall event in early November with other small rainfall events being of no significance. Irrigations of 2-5 hours were made at approximately 5 day intervals or 5 days after rainfall, with a few exceptions. The results from the soil moisture monitoring over the period (Enviroscan Graph 1) show high soil moisture levels for the two rainfall events with a dip in soil moisture in the middle. Further discussion of the results to follow will show that this dip in soil moisture between rainfall events coincides with a reduction in crop growth rate. Overall results indicate the irrigation interval should be reduced to every 4 days at 3 hours to meet crop demand. This irrigation timing will also place the water in the top 30cm where the majority of crop water use takes place. Tensiometers were found to be a useful tool for irrigation scheduling with an indication that a reading of 40 indicates irrigation should commence.

Crop water use through the soil profile

Results indicate the majority (73-90%) of the crop water use occurs in the top 30cm of soil and almost all crop water is used within the top 50cm of soil.

Table 11: Summary of crop water use through the profile

Interpolated Soil Moisture (mm) Content to 70cm	Daily Crop water use (mm)	Sensor depth (cm)	% Soil moisture used at various depths	% Soil moisture used from the 0-50cm zone
140-150 mm	13-15 mm	10-30 cm	73-65	95-100
		50	24-35	
		70	3-0	
115-130	12-14	10-30	80	95
		50	15	
		70	0-5	
100	7-10	10-30	90	95-100
		50	5-10	
		70	0-1	

Penetration of the irrigation water through the soil profile

There was a clear trend for the increased irrigation timing to push the water further through the soil profile. However, all irrigation times placed the water in an ideal position throughout the soil profile for crop access.

Table 12: Summary of the penetration of irrigation water through the profile

Sensor Depth (cm)	% Increase in soil moisture		
	2 hour Irrigation	3 hour Irrigation	5 hour Irrigation
10 -20cm	90%	74%	58%
30	10%	26%	29%
50	0	0	12%
70	0	0	1%

Soil moisture content and stem growth

A correlation between stem growth and soil moisture was apparent. The lowest crop growth rate (on 27th October) was associated with the lowest soil moisture reading (89mm).

Table 13: Soil moisture readings and stem growth rate

Time Period	Soil Moisture Content (mm) to 70cm	Stem Growth Rate cm/day	Crop Water Use mm/day
6-7 th Oct	128 - 116	-	12.9
13-17 th Oct	155 - 107	0.24 - 0.12	12.8 – 9
23-27 th Oct	124 - 89	0.12 - 0.09	10.7 - 6.2
1-3 rd Nov	112 - 96	0.09 – 0.4	8 – 7
10-13 th Nov	164 - 128	0.52	14.9 – 10.6

Calibration of the tensiometer.

Enviroscan graph 6 shows the individual soil moisture content changes with the sensor placed at 30cm. The Tensiometer was placed at the same soil depth. A reading of 40 on the Tensiometer indicates the need for irrigation.

Table 14: Information required for the calibration of the Tensiometer

Tensiometer Reading	30cm Sensor reading (mm)	Crop water use (mm) at 30cm	Date	Stem growth rate (cm/day)
20	25	2.1	10 th Nov	0.52
30	19	2.6	20 th Oct	0.12 to 0.24
40	12	1.3	27 th Oct	0.09 to 0.1

CONCLUSIONS

1. The effective crop rooting depth for this crop of Pink Ice was 50cm.
2. Irrigation events placed the water within the effective root zone.
3. A correlation between soil moisture content and crop growth was established with maximum crop growth of 0.5cm/day at peak soil moisture and 0.09cm/day at the lowest soil moisture levels.
4. Irrigation events need to be shortened to every 4 days to meet crop demand.
5. A Tensiometers reading of 40 was a good indicator of a need for an irrigation